

EVALUATION PROGRAM
for
SECONDARY SPACECRAFT CELLS
INITIAL EVALUATION TESTS
OF
GULTON INDUSTRIES, INCORPORATED
20.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS
WITH AUXILIARY ELECTRODES

prepared for
GODDARD SPACE FLIGHT CENTER
CONTRACT S-23404-G

QUALITY EVALUATION AND ENGINEERING LABORATORY
NAD CRANE, INDIANA

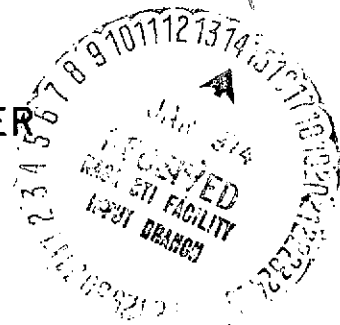
NASA-CR-136318) EVALUATION PROGRAM FOR
SECONDARY SPACECRAFT CELLS: INITIAL
EVALUATION TESTS OF GULTON INDUSTRIES,
INCORPORATED, 20.0 (Naval Ammunition
Depot) -23-P HC \$3 25

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DEPARTMENT OF THE NAVY
NAVAL AMMUNITION DEPOT
CRANE, INDIANA 47522

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3053-JDH:wh
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11 JAN 1974

From: Commanding Officer, Naval Ammunition Depot, Crane, Indiana
To: National Aeronautics and Space Administration, Goddard Space
Flight Center (761, Mr. T. J. Hennigan), Greenbelt,
Maryland 20771

Subj: Report QEEL/C 74-2; Evaluation program for secondary spacecraft
cells; initial evaluation tests of 20.0 ampere-hour nickel-cadmium
spacecraft cells with auxiliary electrodes manufactured by Gulton
Industries, Incorporated

Ref: NASA Purchase Order S-23404-G

Encl: (1) Report QEEL/C 74-2

1. In compliance with reference (a), enclosure (1) is forwarded for
information and retention.


D. G. MILEY
By direction

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DEPARTMENT OF THE NAVY
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QUALITY EVALUATION AND ENGINEERING LABORATORY
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EVALUATION PROGRAM
FOR
SECONDARY SPACECRAFT CELLS

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OF
GULTON INDUSTRIES, INCORPORATED
20.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS
WITH AUXILIARY ELECTRODES

QEEL/C 74-2

4 JANUARY 1974

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REPORT BRIEF
GULTON INDUSTRIES, INCORPORATED
20.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS
WITH AUXILIARY ELECTRODES

Ref: (a) NASA P.O. S-23404-G
(b) Initial Evaluation Test Procedure for Nickel-Cadmium Sealed
Space Cells: NAD 3053-TP324, 10 Apr 73

I. TEST ASSIGNMENT BRIEF

A. The purpose of this evaluation test program is to insure that all cells put into the life cycle program are of high quality by the screening of cells found to have electrolyte leakage, internal shorts, low capacity, or inability of any cell to recover its open circuit voltage above 1.150 volts during the internal short test.

B. The 23 cells were manufactured for the National Aeronautics and Space Administration, Goddard Space Flight Center, under contract number NAS 5-17365, by Gulton Industries, Incorporated, Metuchen, New Jersey. All the cells had sintered, nickel plaque auxiliary electrodes, located along the full length of the narrow face of the cell, and were rated at 20.0 ampere-hours (manufacturer model number VO20HSAD). The cells contain double ceramic seals, and were fitted with pressure gauge assemblies prior to testing. The cells were designated into three groups in which the amount of electrolyte was varied for each group as follows:

<u>Group</u>	<u>Number of Cells</u>	<u>Designation and Amount of Electrolyte (cubic centimeters)</u>
1	8	Control (69)
2	7	20% Increase (82)
3	8	40% Increase (106)

The testing was funded in accordance with reference (a).

C. Test limits specify those values in which a cell is to be terminated from a particular charge or discharge. Requirements are referred to as normally expected values based on past performance of aerospace nickel-cadmium cells with demonstrated life characteristics. A requirement does not constitute a limit for discontinuance from test.

II. SUMMARY OF RESULTS.

A. The capacity of the cells ranged from 23.5 to 26.7 ampere-hours during the three capacity tests.

B. During the capacity tests only one cell from Group 3 (106 cc electrolyte) was terminated from charge due to high voltage, whereas the other cells of this group were terminated because of high pressure (100 psia). Group 2 (82 cc electrolyte) had one cell terminated from charge during capacity test #2 and three during capacity test #3 due to high pressure.

C. The voltage requirement of 1.480 volts was exceeded by one cell of Group 1 during the second and third capacity tests while Group 2 had three cells exceed this voltage during the last capacity test and Group 3 had one cell over 1.480 volts during capacity test #2 and five cells during capacity test #3. Also, the end-of-charge voltage of these cells was over this value.

D. During the auxiliary electrode characteristic tests, maximum signal power was obtained with a 20-ohm resistance; but a 47-ohm resistance, approximately 92 percent of maximum power, was used as requested by the Goddard Space Flight Center representative for the remainder of the test.

E. The 24-hour average cell voltage following a 16-hour short period, for groups 1, 2 and 3, was 1.196, 1.186 and 1.164 volts respectively.

F. Average capacity out during the 20°C charge efficiency test was 7.5, 6.8 and 6.7 ampere-hours respectively for groups 1, 2 and 3.

G. All cells exceeded the requirement of 1.520 volts during the 0°C overcharge test and two cells from Group 1 and one cell each from Groups 2 and 3 were terminated from charge due to high cell voltage (1.560 volts for 2 hours). Three cells from Group 2 and seven cells from Group 3 were terminated due to high pressure (100 psia). Average capacity out for groups 1, 2 and 3 were 24.3, 24.8 and 23.7 ampere-hours respectively.

H. All cells of Group 3 and two cells of Group 2 were terminated from charge during the 35°C overcharge test because of high pressure (100 psia). Average capacity out for groups 1, 2 and 3 were 20.1, 23.6 and 25.2 ampere-hours respectively.

I. Following the 35°C overcharge test, it was requested by the Goddard Space Flight Center representative that the cells receive a charge (1.0 ampere) at 25°C for 20 hours, followed by a discharge (10.0 amperes) to obtain a measurement of the cells' efficiency at this temperature. Average ampere-hour capacity out was 14.1, 14.7 and 15.4 ampere-hours respectively for groups 1, 2 and 3.

J. The cells exhibited no pressure decay during the open-circuit stand portion of the pressure versus capacity test. Cells of Groups 1 and 2 reached their voltage limit (1.550 volts) before obtaining a pressure of 20 psia. Five cells of Group 3 also reached the voltage limit before the pressure limit and two cells reached voltage and pressure limits at the same time. One cell from this group had a pressure gauge assembly leak and was charged to 1.550 volts. Average capacity in and out, for groups 1, 2 and 3, was 28.0, 29.9, 30.4, and 23.0, 24.4, 24.5 ampere-hours respectively.

K. Two cells were found to have leaks following test--cell, S/N 529, at the base of its fill tube and cell, S/N 554, in its gauge assembly.

III. RECOMMENDATIONS

A. It was recommended that each group of cells (excluding the leakers) be placed on a life cycle test program to evaluate the effects of increased quantities of electrolyte with life performance.

B. On 24 October 1973, five cells from each group began life testing (Packs 1D, 1E and 1F) on a 90-minute orbit (1-hour charge) at 20°C with voltage limit control.

RESULTS OF INITIAL EVALUATION TESTS
GULTON INDUSTRIES, INCORPORATED
20.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS
WITH AUXILIARY ELECTRODES

I. TEST CONDITIONS AND PROCEDURE

A. All evaluation tests were performed at room ambient (RA) pressure and temperature ($25^{\circ}\text{C} \pm 2^{\circ}\text{C}$) with discharges at the 2-hour rate, and in accordance with reference (b), unless otherwise specified, and consisted of the following:

1. Phenolphthalein leak tests (2).
2. Three capacity tests, third at 20°C ; with internal resistance measurements during second charge/discharge.
3. Auxiliary electrode characterization test.
4. Internal short test.
5. Charge efficiency test, 20°C .
6. Overcharge tests, 0°C and 35°C .
7. Pressure versus capacity test.
8. Phenolphthalein leak test.

See Appendix I for summary of test procedure.

II. CELL IDENTIFICATION AND DESCRIPTION

A. The cells were identified by the manufacturer's serial numbers and placed in pack configurations according to the amount of electrolyte in each cell. The designation of the cells into groups and temporary pack number they were tested under is as follows:

<u>Group</u>	<u>Pack No.</u>	<u>No. of Cells</u>	<u>Designation and Amount of Electrolyte (cc's)</u>
1	500X	8	Control (69)
2	501X	7	20% Increase (82)
3	502X	8	40% Increase (106)

B. The 20.0 ampere-hour cell is rectangular with average physical dimensions as follows:

<u>Height (in.)</u>	<u>Length (in.)</u>	<u>Width (in.)</u>
6.889	0.912	2.999

The weights of the cells varied according to the amount of electrolyte and these are listed in Table I.

C. The cell containers and covers are made of stainless steel. The positive and negative terminals are insulated from the cell cover by ceramic seals and protrude through the cover as solder-type terminals.

D. The auxiliary electrode is a sintered, nickel plaque located along the full length of the narrow face of the cell.

III. RESULTS--THE FOLLOWING WAS CONDENSED FROM TABLES I THROUGH VII:

A. Leak Tests--Cells, S/N 529 and 554, had a leak at the base of the fill tube and in the gauge assembly respectively.

B. Average Capacity (ampere-hours, AH):

<u>Type of Charge</u>	<u>1</u>	<u>GROUP*</u> <u>2</u>	<u>3</u>
C/20, 48 hours RA	25.4	25.7	24.9
C/10, 24 hours RA**	24.6	25.2	25.2
C/10, 24 hours 20°C**	23.9	24.8	25.4

*AH Out.

**All groups had cells exceed the voltage requirement of 1.480 volts and Groups 2 and 3 had cells terminated from charge due to high pressure (100 psia). This data is shown in Table II.

C. Average Internal Resistance Measurement (milliohms):

<u>Measurement Taken</u>	<u>1</u>	<u>GROUP</u> <u>2</u>	<u>3</u>
30 min. before end-of charge	4.6	4.1	3.9
1 hr. after start-of-discharge	4.2	3.6	4.0
2 hrs. after start-of-discharge	3.9	3.8	3.8

D. Maximum power was obtained with a 20-ohm resistor during the resistance characteristic test, although a 47-ohm resistor was used throughout the tests as instructed by the Goddard Space Flight Center Technical Officer.

E. The 24-hour average cell voltage following a 16-hour short period, during the internal short test, was 1.196, 1.186 and 1.164 volts respectively for the three groups.

F. Average capacity out during the 20°C charge efficiency test was as follows:

	<u>1</u>	<u>GROUP 2</u>	<u>3</u>
AH Out	7.5	6.8	6.7

G. Average capacity out during the 0°C overcharge test was as follows:

	<u>1</u>	<u>GROUP* 2**</u>	<u>3**</u>
AH Out	24.3	24.8	23.7

*All cells exceeded the requirement of 1.520 volts during charge and two cells from Group 1 and one cell each from Groups 2 and 3 were terminated from charge because of high cell voltage (1.560 volts for 2 hours).

**Three cells from Group 2 and seven cells from Group 3 were terminated from charge because of high pressure (100 psia).

H. Average capacity out during the 35°C overcharge test was as follows:

	<u>1</u>	<u>GROUP 2*</u>	<u>3**</u>
AH Out	20.1	23.6	25.2

*Two cells reached pressure limit.

**All cells reached pressure limit.

I. The Goddard Space Flight Center representative requested that a charge efficiency test be run at 25°C with a charge rate of 1.0 ampere for 20 hours. The average capacity out following this charge was 14.1, 14.7 and 15.4 ampere-hours respectively for the three groups.

J. Average capacity in and out during the pressure versus capacity test is as follows:

	<u>1**</u>	<u>GROUP*</u> <u>2**</u>	<u>3***</u>
AH In	28.0	29.9	30.4
AH Out	23.0	24.4	24.5

*No cells showed a pressure decay during the 1-hour open-circuit stand following charge.

**All cells reached the voltage limit (1.550 volts) before obtaining a pressure of 20 psia.

***Five cells reached their voltage limit first and two cells reached both limits at the same time. One cell had a gauge assembly leak and was charged to 1.550 volts.

QEEL/C 74-2

APPENDIX I

APPENDIX I

I. TEST PROCEDURE

A. Phenolphthalein Leak Tests:

1. This test is a determination of the condition of the welds and ceramic seals on receipt of the cells and following the last discharge of the cells (Cycle #7).

2. The cells were initially checked with a one-half of one percent phenolphthalein solution applied with a cotton swab and then placed in a vacuum chamber and exposed to a vacuum of 40 microns of mercury or less for 24 hours. Upon removal they were rechecked for leaks and then received a final check following test completion. The requirement is no red or pink discoloration which indicates a leak.

B. Capacity Tests:

1. The capacity test is a determination of the cells' capacity at the C/2 discharge rate to 0.75 volt per cell, where C is the manufacturer's rated capacity. This type discharge follows all charges of this evaluation test.

2. The charges for the capacity tests are as follows:

a. C/20, 48 hours, room ambient (R.A.), Cycle 0, with a test limit of 1.52 volts or pressure of 100 psia.

b. C/10, 24 hours, R.A., Cycle 1, with a test limit of 1.52 volts or 100 psia pressure and a requirement of maximum voltage (1.48) or pressure (65 psia).

c. C/10, 24 hours, 20°C, Cycle 2, with the same limits and requirements as the charge of Cycle 1.

C. Special Resistance Characterization Tests for Auxiliary Electrode Cells:

1. The purpose of this test is to determine the resistance to be placed across the cell's auxiliary electrode and negative terminal which will provide maximum signal when the cell is fully charged.

2. The cells are charged at C/10 for 24 hours at the room ambient temperature following their initial charge/discharge cycle. Following this the cells are continued on charge with the current reduced, if necessary, to maintain the cell's voltage below 1.520 volts

and to stabilize the pressure between 10-20 psia. Resistance values, between 10,000 ohms and 0.1 ohm are then placed between the auxiliary electrode and the negative terminal. The cells are allowed a minimum of 5 minutes, at each resistance value, to obtain an equilibrium voltage across this resistance. This voltage value is then recorded and by calculation using the equation $P = E^2/R$ the resistance that produces maximum power is determined.

D. Internal Resistance:

1. Measurements are taken across the cell terminals 1/2 hour before the end-of-charge (EOC) on Cycle 1 and 1 and 2 hours after the start-of-discharge of Cycle 2. These measurements were made with a Hewlett-Packard milliohmmeter (Model 4328A).

E. Internal Short Test:

1. This test is a means of detecting slight shorting conditions which may exist because of imperfections in the insulating materials, or damage to element in handling or assembly.

2. Following completion of the third capacity discharge, the cells are shunted with a 0.5-ohm, 3-watt resistor for 16 hours. At the end of 16 hours the resistors are removed and the cells stand on open-circuit-voltage (OCV) for 24 hours. A minimum voltage of 1.15 is required at the end of 24 hours.

F. Charge Efficiency Test, 20°C:

1. This test is a measurement of the cells' charge efficiency when charged at a low current rate.

2. The cells are charged at C/40 for 20 hours with a test limit of 1.52 volts or 100 psia pressure. They are then discharged and the requirement is that the minimum capacity out equals 55 percent of capacity in during the preceding charge.

G. Overcharge Test #1, 0°C:

1. The purpose of this test is to determine the degree to which the cells will maintain a balanced voltage, and to determine the cells' capability to be overcharged without overcharging the negative electrode.

2. The cells are charged at C/20 for 60 hours. The test limits are cell voltages of 1.56 or greater for a continuous time

period of 2 hours or pressures of 100 psia. The requirement is a voltage of 1.520 or a pressure of 65 psia. The cells are then discharged and 85 percent capacity out of that obtained in Cycle 3 is required.

H. Overcharge Test #2, 35°C:

1. This test is a measurement of the cells' capacity at a higher temperature when compared to its capacity at 20°C. This test also determines the cells' capability of reaching a point of pressure equilibrium; oxygen recombination at the negative plate at the same rate it is being generated at the positive plate.

2. The cells are charged at C/10 for 24 hours with a test limit of 1.52 volts or 100 psia pressure and a requirement of 1.45 volts or 65 psia pressure. The cells are then discharged with a requirement that capacity out equals 55 percent capacity out as obtained in Cycle 3.

I. Pressure versus Capacity Test:

1. The purpose of this test is to determine the capacity to a pressure and the pressure decay during charge and open circuit stand respectively.

2. Each cell is charged at C/2 to either a pressure of 20 psia or a voltage of 1.550. Recordings are taken on each cell when it reaches 5, 10, 15 and 20 psia pressure. The cells then stand OCV for 1 hour with 30-minute recordings and then are discharged, shorted out and leak tested.

TABLE I

[illegible]

TABLE II
Capacity Data

SERIAL NUMBER	Capacity Test 1						Capacity Test 2						Capacity Test 3 (20°C)					
	END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE		
	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPAC- ITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPAC- ITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPAC- ITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)
543	1.432	.355*	35	25.4	-.112*	8	1.453	.829	55	24.4	.098	11	1.464	.830	66	23.5	.342	18
545	1.428	.372*	30	25.0	-.129*	6	1.447	.838	65	24.0	.125	10	1.460	.841	77	23.5	-.260	20
549	1.429	.419*	33	25.4	-.018*	4	1.447	.842	61	24.4	.280	9	1.463	.845	67	23.9	.154	18
550	1.425	.396*	37	25.8	-.061*	10	1.452	.900	54	25.1	.081	11	1.464	.823	67	23.9	.275	17
551	1.428	.337*	21	25.4	-.233*	5	1.450	.722	29	24.7	-.060	6	1.467	.731	37	24.3	.005	7
552	1.425	.357*	47	25.0	-.035*	7	1.449	.795	68	24.4	.113	7	1.463	.801	88	23.5	-.197	22
553	1.427	.406*	45	25.8	.030*	12	1.456	.824	60	25.1	.166	14	1.470	.834	75	24.3	-.054	6
554	1.439	.291*	21	25.0	-.137*	11	1.489	.557	22	24.7	.000	13	1.532	.472	12	24.3	-.144	13
529	1.436	.604	42	25.9	.034	5	1.453	.773	85	25.1	.047	7	1.471	.740	93	25.3	.100	14
530	1.437	.287	22	26.3	.106	5	1.461	.521	28	25.9	.153	7	1.485	.463	33	26.2	.144	7
531	1.463	.483	12	26.7	.198	11	1.468	.524	54	26.3	.225	8	1.497	.490	51	26.2	.067	14
532	1.428	.544	25	25.1	-.032	0	1.449	.745	73	24.7	.150	5	1.472	.748	100**	23.7	.211	11
533	1.430	.585	35	25.9	-.010	7°	1.447	.833	100**	24.7	.029	16	1.485	.785	100**	23.7	.197	10
537	1.430	.622	47	25.1	.167	3	1.459	.706	80	24.7	.144	7	1.476	.724	95	24.5	.231	15
538	1.433	.669	51	25.1	.173	10	1.457	.823	99	25.1	.172	14	1.474	.787	109**	24.1	.183	15
534	1.450	.579	67	24.8	.272	21	1.462	.435	100**	24.2	.103	9	1.477	.483	100**	24.5	.337	49
536	1.445	.551	100**	24.4	.133	13	1.467	.373	118**	24.6	.280	18	1.483	.233	100**	25.3	.374	52
539	1.437	.604	102**	24.8	.020	10°	1.463	.596	114**	25.0	.150	20	1.475	.562	100**	25.3	.384	59
540	1.445	.673	105**	24.0	.068	8	1.468	.314	108**	24.6	.345	36	1.474	.281	100**	24.9	.369	63
541	1.461	.468	66	25.6	.324	18	1.548	.313	83	26.2	.131	21	1.565	.355	60	24.9	.124	24
542	1.440	.661	100**	24.8	.099	6	1.465	.373	100**	25.4	.160	19	1.486	.339	100**	25.7	.360	48
547	1.446	.566	100**	25.6	.209	15	1.467	.349	117**	26.2	.194	17	1.484	.274	100**	26.5	.309	56
548	1.446	.634	100**	24.8	.227	19	1.470	.391	112**	25.4	.233	25	1.485	.299	100**	25.7	.433	51
□	CELL REVERSED ON DISCHARGE (-22 VOLTS)						- OFF DURING CHARGE-NICH VOLTAGE											

9ND-RADC (SP 11/73)

* 100HM AUXILIARY ELECTRODE RESISTORS DURING CHARGE/DISCHARGE

0- GAUGE ASSEMBLY CHANGED

** OFF DURING CHARGE
HIGH PRESSURE

TABLE III
INTERNAL RESISTANCE AND SHORT TEST DATA

[illegible]

TABLE IV
Charge Efficiency and Overcharge Data

SERIAL NUMBER	Charge Efficiency (20°C)						Overcharge Test (0°C)						Overcharge Test (35°C)					
	END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE		
	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPAC- ITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPAC- ITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPAC- ITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)
543	1.367	.137	7	7.6 *	-.123	7	1.530	.363	30	23.9	.148	17	1.396	.828	74	20.6	.048	16
545	1.367	.176	8	7.6 *	.000	8	1.560	.320	27	24.7	.053	14	1.393	.834	75	19.2	.240	14
549	1.366	.193	5	7.6 *	-.084	5	1.536	.397	33	24.6	.153	21	1.391	.839	84	19.8	.231	17
550	1.366	.176	11	7.6 *	.050	10	1.547	.278	49	24.6	.034	36	1.390	.834	85	20.2	.310	20
551	1.367	.033	5	7.2 *	-.040	37 **	1.570	.358	16	25.0	-.051	17	1.394	.765	41	20.6	.011	16
552	1.367	.175	5	7.6 *	-.253	9	1.530	.452	41	23.8	-.202	22	1.391	.829	93	19.0	.034	19
553	1.366	.161	11	7.6 *	-.195	15 **	1.534	.470	44	24.3	.215	31	1.392	.839	83	19.6	.150	22
554	1.368	.031	5	7.2 *	-.033	41 **	1.593	.433	26	23.4	-.143	13	1.403	.573	19	21.4	.073	5
529	1.364	.043	4	6.2	.027	5	1.533	.446	57	26.6	.017	21	1.404	.778	79	22.5	.133	12
530	1.362	.050	13	6.6	.040	13	1.541	.095	46	26.6	.094	24	1.413	.529	36	23.7	.213	7
531	1.363	.028	4	6.6 *	-.001	5	1.593	.483	57	24.6	.242	9	1.419	.515	52	24.7	.193	14
532	1.363	.083	1	7.4	-.005	1	1.535	.557	100°	23.2	.140	17	1.416	.818	97	24.1	.311	22
533	1.362	.108	8	7.4	.024	8	1.540	.582	101°	23.4	.282	32	1.419	.824	104°	23.5	.529	29
537	1.364	.046	4	6.6 *	.021	1	1.533	.502	64	25.8	.137	21	1.416	.575	63	23.3	.147	14
538	1.363	.093	8	6.6	.014	8	1.536	.539	100°	23.4	.055	17	1.426	.831	100°	23.3	.253	21
534	1.365	.050	5	6.8 *	-.038	6	1.515	.416	103°	23.0	.218	60	1.432	.272	100°	24.5	.363	35
536	1.364	.027	6	6.4 *	.006	6	1.519	.432	100°	23.4	.043	24	1.436	.241	102°	24.9	.326	29
539	1.365	.013	3	6.8 *	-.003	15 **	1.503	.485	115°	23.8	.158	58	1.430	.420	117°	25.3	.244	30
540	1.364	.061	20	6.8	.007	20	1.527	.415	100°	23.4	.114	57	1.438	.296	120°	24.7	.394	52
541	1.363	.030	16	6.8	.002	16	1.605	.504	100°	23.6	.005	21	1.511	.318	101°	25.5	.108	16
542	1.363	.017	8	6.8	.007	8	1.530	.440	115°	23.8	.149	57	1.440	.332	115°	25.3	.384	46
547	1.364	.079	6	6.8 *	.005	6	1.525	.407	115°	24.2	.157	66	1.435	.263	105°	26.3	.442	47
548	1.365	.019	10	6.4 *	.005	10	1.519	.458	104°	24.0	.175	39	1.439	.329	109°	25.3	.401	36
*	REVERSED ON DISCHARGE (-10 TO -24 VOLTS)																	

9ND-NADC (SP 11/73)

** VACUUM PULLED AFTER SHORTED 24 HOURS.

D OFF DURING CHARGE - HIGH VOLTAGE
O OFF DURING CHARGE - HIGH PRESSURE

CONTROL CELLS
PRESSURE VS. CAPACITY TEST DATA

20% INCREASE CELLS

Serial No.	543	545	549	550	551	552	553	554		529	530	531	532	533	537	538
Start-of-Charge, Press.	5	5	2	4	4	2	7	4		4	2	4	1	3	4	3
AH in to 5 PSIA	0	0	26.7	3.3	20.0	26.7	0	23.3		8.3	28.3	11.7	26.7	28.3	18.3	25.0
Cell (volts)	1.414	1.444	1.523	1.413	1.460	1.525	1.412	1.476		1.4118	1.494	1.424	1.489	1.518	1.442	1.469
Aux (volts)	.031	.038	.134	.036	.053	.155	.033	.060		.034	.122	.028	.073	.166	.040	.095
AH in to 10 PSIA	N.A.	N.A.		28.3			28.3			30.0				29.6		
Cell (volts)	1.548	1.550		1.548			1.547			1.521				1.545		
Aux (volts)	.158	.194		.215			.217			.194				.220		
AH in to 15 PSIA										N.A.						
Cell (volts)																
Aux (volts)																
AH in to 20 PSIA																
Cell (volts)																
Aux (volts)																
AH in to V/L (1.55V)	27.7	27.3	28.2	28.8	27.8	28.3	29.0	26.8		31.3	30.0	29.7	29.3	29.7	29.8	29.8
Aux (volts)	.161	.194	.154	.229	.237	.184	.217	.159		.308	.257	.243	.185	.221	.280	.243
Press (PSIA)	11	10	8	11	9	9	12	6		19	9	14	14	11	22	17
30 Min OCV, Cell	1.396	1.395	1.396	1.396	1.399	1.398	1.397	1.394		1.404	1.397	1.393	1.398	1.396	1.398	1.401
Aux (volts)	.219	.265	.276	.304	.303	.285	.295	.196		.359	.305	.301	.297	.286	.329	.346
Press (PSIA)	12	12	9	14	9	12	14	6		23	8	7	15	15	19	23
1 hour OCV, Cell	1.388	1.387	1.388	1.388	1.389	1.390	1.389	1.386		1.394	1.389	1.386	1.391	1.389	1.390	1.393
Aux (volts)	.216	.233	.276	.301	.247	.283	.295	.172		.355	.283	.283	.288	.285	.314	.345
Press (PSIA)	12	11	9	14	8	12	14	6		21	7	N.A.	16	14	18	23
EOD AH out	22.8	22.2	23.2	23.6	22.8	23.4	24.0	23.2		25.0	24.4	24.6	24.0	24.4	24.2	24.4
Aux (volts)	.048	.082	.084	.083	-.136	-.114	.070	-.015		.111	.153	.137	.175	.205	.171	.232
Press (PSIA)	8	9	7	10	5	6	11	4		10	3	7	10	10	8	14

N.A. - NOT AVAILABLE

40% INCREASE CELLS TABLE V
PRESSURE VS. CAPACITY TEST DATA

Serial No.	534	536	539	540	541	542	547	548									
Start-of-Charge, Press.	3	3	4	5	*	4	5	6									
AH in to 5 PSIA	23.3	25.8	18.3			23.3											
Cell (volts)	1.461	1.474	1.445			1.455											
Aux (volts)	.057	.107	.019			.049											
AH in to 10 PSIA	28.3	29.2	27.5	26.7		28.3	N.A.	28.0									
Cell (volts)	1.502	1.511	1.485	1.476		1.490		1.490									
Aux (volts)	.095	.144	.099	.066		.092		.120									
AH in to 15 PSIA	N.A.	N.A.	N.A.	N.A.		N.A.	30.3	N.A.									
Cell (volts)			1.505	1.514			1.520										
Aux (volts)			.130	.101			.143										
AH in to 20 PSIA	29.8	30.2	30.0	30.7		31.0	31.2	31.0									
Cell (volts)	1.540	1.549	1.531	1.550		1.549	1.529	1.550									
Aux (volts)	.136	.179	.166	.180		.155	.152	.194									
AH in to V/L (1.55V)				30.7	29.5			31.0									
Aux (volts)				.180	.180			.194									
Press (PSIA)				5				5									
30 Min OCV, Cell	1.410	1.410	1.401	1.411	1.401	1.409	1.406	1.410									
Aux (volts)	.141	.148	.248	.159	.188	.167	.158	.199									
Press (PSIA)	31	32	35	38	26	45	27	45									
1 hour OCV, Cell	1.400	1.399	1.392	1.401	1.392	1.398	1.397	1.399									
Aux (volts)	.208	.147	.318	.158	.189	.198	.164	.196									
Press (PSIA)	32	33	36	39	24	45	25	45									
EOD AH out	24.0	24.4	24.5	24.4	23.7	24.9	25.3	24.8									
Aux (volts)	.267	.215	.227	.242	.202	.262	.232	.305									
Press (PSIA)	20	18	23	24	14	23	18	26									

* - GAGE ASSEMBLY LEAK- CHARGED TO 1.550 VOLTS
N.A. = Not Available

TABLE VI PART A (Control Cells)

SND-NADC (SF 11/73)

SPECIAL RESISTANCE CHARACTERISTIC DATA ON THE AUXILIARY ELECTRODES

SERIAL NO.	543		545		549						AVERAGE	
	OHMS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	MILLIWATTS
10,000		.871	30	.880	25	.880	26			.877		.07
5,000		.881	30	.888	25	.890	26			.886		.16
2,000		.882	30	.885	24	.889	26			.885		.39
1,000		.878	30	.879	24	.884	26			.880		.77
500		.868	30	.867	24	.873	26			.869		1.51
200		.845	30	.841	24	.850	26			.845		3.57
100		.804	30	.784	24	.813	26			.800		6.40
50		N/A	30	.632	25	.698	26			.665		8.84
20		N/A	30	.394	25	.457	26			.425		9.05
10		.242	30	.266	25	.314	26			.274		7.51
5		.177	30	.176	25	.213	26			.188		7.12
2		.098	30	.097	25	.122	26			.106		5.58
1		.063	30	.060	25	.078	26			.067		4.49
0.5		.041	30	.038	25	.051	26			.043		3.75
0.2		.032	30	.023	25	.031	26			.029		4.11
0.1		.027	30	.017	25	.024	26			.023		5.14

Note: All pressures in PSIA.

$$\text{POWER} = \frac{V^2}{R} \text{ Watts } 10^3 \frac{\text{Milliwatts}}{\text{Watt}} : \text{Milliwatts}$$

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TABLE VI PART B (20% Increase Cells)

SPECIAL RESISTANCE CHARACTERISTIC DATA ON THE AUXILIARY ELECTRODES

91D-NADC (SP 11/73)

SERIAL NO.	529		532		533						AVERAGE	
OHMS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	MILLIWATTS
10,000	.855	31	.863	26	.886	42					.868	.07
5,000	.871	31	.872	26	.892	42					.878	.20
2,000	.874	31	.873	26	.889	42					.878	.50
1,000	.869	31	.866	26	.883	42					.872	.76
500	.853	31	.850	25	.870	42					.857	1.71
200	.772	31	.750	25	.825	42					.782	3.06
100	.620	31	.600	25	.717	42					.646	4.17
50	.460	30	.454	25	.563	42					.492	4.84
20	.292	30	.300	25	.386	42					.326	5.31
10	.201	30	.211	25	.275	41					.229	5.24
5	.133	30	.141	25	.189	41					.154	4.74
2	.074	30	.078	25	.109	41					.087	3.78
1	.048	30	.049	25	.069	41					.055	3.03
0.5	.031	29	.031	25	.042	41					.035	2.40
0.2	.021	29	.019	25	.026	40					.022	2.42
0.1	.017	29	.015	25	.019	40					.017	2.89

Note: All pressures in PSIA.

$$\text{POWER} = \frac{V^2}{R} \text{ Watts } 10^3 \frac{\text{Milliwatts}}{\text{Watt}} : \text{Milliwatts}$$

TABLE VI PART C (40% Increase Cells)

9ND-NADC (SF 11/73)

SPECIAL RESISTANCE CHARACTERISTIC DATA ON THE AUXILIARY ELECTRODES

SERIAL NO.	540		541		542						AVERAGE *	
OHMS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	MILLIWATTS
10,000	.833	54	.429	40	.881	41					.882	.08
5,000	.850	54	.478	40	.879	41					.864	.15
2,000	.850	54	.521	40	.864	41					.857	.37
1,000	.833	54	.543	40	.830	41					.831	.69
500	.785	54	.543	41	.760	41					.772	1.19
200	.690	54	.458	41	.656	42					.673	2.26
100	.614	54	.347	41	.569	42					.591	3.49
50	.529	54	.254	41	.443	42					.486	4.72
20	.377	54	.159	41	.279	42					.328	5.38
10	.222	54	.119	41	.184	42					.203	4.12
5	.141	54	.092	40	.118	42					.129	3.33
2	.078	54	.056	39	.063	42					.070	2.45
1	.049	54	.032	39	.037	42					.043	1.85
0.5	.031	54	.018	39	.023	42					.027	1.46
0.2	.020	54	.010	39	.013	42					.016	1.28
0.1	.016	54	.007	39	.010	42					.013	1.69

Note: All pressures in PSIA.

$$\text{POWER} = \frac{V^2}{R} \text{ Watts } 10^3 \frac{\text{Milliwatts}}{\text{Watt}} : \text{Milliwatts}$$

* AVERAGE ON S/N'S 540 AND 542 ONLY.

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TABLE VII
CHARGE EFFICIENCY DATA

SERIAL NUMBER	CHARGE EFFICIENCY (25°C)																	
	END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE		
	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPAC- ITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPAC- ITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPAC- ITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)
543	1.402	.203	9	13.8	-.178	8												
545	1.403	.200	7	14.4	-.054	6												
549	1.402	.255	6	14.2*	-.559	6												
550	1.402	.266	12	14.2	-.178	12												
551	1.400	.141	13	14.4	-.234	13												
552	1.402	.224	6	13.6*	-.571	6												
553	1.401	.239	12	13.8*	-.595	10												
554	1.401	.140	4	14.4	-.103	3												
529	1.395	.183	8	14.4	.011	8												
530	1.394	.145	14	14.6	.100	13												
531	1.393	.102	7	15.0	.091	6												
532	1.396	.117	5	14.8*	-.474	4												
533	1.395	.140	12	14.6	-.539	11												
537	1.395	.170	7	14.8	.014	5												
538	1.393	.189	12	14.8	.005	11												
534	1.392	.053	8	15.5*	.016	8												
536	1.391	.078	9	15.5*	.017	9												
539	1.391	.086	6	15.1	-.302	6												
540	1.392	.039	19	15.5*	-.001	18												
541	1.391	.107	16	16.3*	.053	15												
542	1.391	.047	14	15.5*	.022	14												
547	1.390	.051	10	15.5*	.006	10												
548	1.391	.056	13	15.5*	.026	13												

9ND-NADC (SP 11/73) * CELL REVERSED ON DISCHARGE